A Concept of International Nano-Launcher

Kazuhiro Yagi
Seiji Matsuda
Jun Yokote

IHI Aerospace Co., Ltd.

K. Yagi, S. Matsuda, J. Yokote
T. Fuji, K. Sasaki
Shinichiro Tokudome, Yohsuke Nambu
M. Kaneoka

IHI Aerospace Co., Ltd.
IHI Aerospace Company Overview
Products
Nano Satellite Revolution
Space Technology Innovation
Phased Development of Nano Launcher
Evolution of New Sounding Rocket and Nano Launcher
Nano Launch Vehicle Configuration
NL-520 Nano Satellite Launcher
Payload Configuration of NL-520
Small Satellite Launch Vehicle Commercialization Strategy
Summary
  – Backup Slide
Company Overview

• IHI Aerospace Co., Ltd. (IA) is Japanese Solid LVS Manufacturer
• Employees : (approx.) 1000
• Sales : (approx.) $400million
• Major Customer : JAXA , MOD, METI(NEDO, USEF)

History:
1924 Aircraft engine plant of Nakajima Aircraft Industries. Co., Ltd.
1945 Fuji Sangyo Co., Ltd.
1950 Fuji Seimitsu Kogyo Co., Ltd.
1961 Prince Motor Co., Ltd.
1966 Nissan Motor Co., Ltd.
2000 IHI Aerospace Co., Ltd.

Mission Statement:
We respect originality, innovation, and harmony with society, and contribute to realization of the human beings' dream, social peace and development with the rocket related technologies.
IA has been a Japanese leading company in the solid rocket development.

- **Sounding rocket flight**: Over 1400
- **Satellite LVS flight**: 27

### Sub-Orbital LVS (Sounding Rocket)

<table>
<thead>
<tr>
<th>Rocket</th>
<th>Total Length (m)</th>
<th>Diameter (m)</th>
<th>Weight (t)</th>
<th>Altitude (km)</th>
<th>Payload (kg)</th>
<th>Flight Year</th>
<th>Launches</th>
</tr>
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<tbody>
<tr>
<td>MT-135</td>
<td>3.3</td>
<td>0.135</td>
<td>0.071</td>
<td>60</td>
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<td>1964</td>
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<td>S-210</td>
<td>5.2</td>
<td>0.21</td>
<td>0.28</td>
<td>110</td>
<td>20</td>
<td>1969</td>
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<td>K-9M</td>
<td>8.8</td>
<td>0.42</td>
<td>1.5</td>
<td>330</td>
<td>55</td>
<td>1969</td>
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<td>K-10</td>
<td>9.8</td>
<td>0.42</td>
<td>1.78</td>
<td>240</td>
<td>132</td>
<td>1965</td>
<td>14</td>
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<tr>
<td>S-310</td>
<td>7.1</td>
<td>0.31</td>
<td>3.7</td>
<td>130</td>
<td>70</td>
<td>1975</td>
<td>38</td>
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<tr>
<td>S-520</td>
<td>9.9</td>
<td>0.52</td>
<td>2.1</td>
<td>360</td>
<td>150</td>
<td>1980</td>
<td>24</td>
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<tr>
<td>SS-520</td>
<td>9.65</td>
<td>0.52</td>
<td>2.6</td>
<td>830</td>
<td>30</td>
<td>1998</td>
<td>2</td>
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### Satellite LVS

<table>
<thead>
<tr>
<th>Rocket</th>
<th>Total Length (m)</th>
<th>Diameter (m)</th>
<th>Weight (t)</th>
<th>Payload to LEO (kg)</th>
<th>Flight Year</th>
<th>Rate (s/I)</th>
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<tbody>
<tr>
<td>L-4S</td>
<td>16.5</td>
<td>0.735</td>
<td>9.4</td>
<td>26kg</td>
<td>1970</td>
<td>1/5</td>
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<tr>
<td>M-4S</td>
<td>23.6</td>
<td>1.41</td>
<td>43.6t</td>
<td>180kg</td>
<td>1971</td>
<td>3/4</td>
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<tr>
<td>M-3C</td>
<td>20.2</td>
<td>1.41</td>
<td>41.6t</td>
<td>195kg</td>
<td>1974</td>
<td>3/4</td>
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<tr>
<td>M-3H</td>
<td>23.8</td>
<td>1.41</td>
<td>48.7t</td>
<td>300kg</td>
<td>1977</td>
<td>3/3</td>
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<tr>
<td>M-3S</td>
<td>23.8</td>
<td>1.41</td>
<td>48.7t</td>
<td>300kg</td>
<td>1980</td>
<td>4/4</td>
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<tr>
<td>M-3SII</td>
<td>27.8</td>
<td>1.41</td>
<td>61t</td>
<td>770kg</td>
<td>1985</td>
<td>7/8</td>
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<tr>
<td>M-V</td>
<td>30.7</td>
<td>2.5</td>
<td>139t</td>
<td>1800kg</td>
<td>1997</td>
<td>6/7</td>
</tr>
</tbody>
</table>

Still in use & Launched from many sites

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Image Source
Nano Satellite Revolution

- Sputnik shock => Gagarin shock => Man on the moon => Cubesat shock?
- Advance in Nano Satellite Technology & Player & Mission
- Limitation on a launch opportunity
- Strong demand for an affordable nano launcher

Nano launcher is critical to the innovative nano space.
Space Technology Innovation

Key Enabling Technologies
Research & Development

Launch Vehicle Technologies
- Miniaturized avionics
- Automated Launch Operation
- Advanced Range Safety Control
- Green propellant thruster

Satellite Technologies
- Miniaturized sensor
- Miniaturized satellite bus
- Formation Flight

Technology Demonstration

New Sounding Rocket

Nano-sat. Launch Vehicle

Spiral Up Cycle of Technology Improvement

- Technology Evolution
- Developers & Users Increase
- Cost Reduction

Encouraging Evolution of Space Systems

Education and Training

Growing Developers & Users of Space Systems

Stimulating Space Business

From Nano Space…

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Phased Development of Nano Launcher

Current

SS-520

Capability A

NS-520

Suborbital mission

Development

S-520

Demonstration of basic technologies for the low-cost launcher

Capability B

NL-520

6 CubeSats per launch

Manufacturing

Privatization

Assembly

Private-led

Launch operation

JAXA/ISAS

Launch operation

JAXA/ISAS

Regulations

Preliminary study

Development

Technology demonstration of low-cost launcher

Enforcement

New launch business model

 Capability C

Commercialization

10 launches per year (we hope more)

• Upper stage motor (high performance)
• Low-cost launch control system
• Multi-satellites adapter

• Economy in scale
• Air launch technology
• International cooperation

• 0 Stage motor
• Light weight & Small low-cost avionics

• 0 Stage motor
• Light weight & Small low-cost avionics
Evolution of New Sounding Rocket and Nano Launcher

<table>
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<tr>
<th></th>
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<tbody>
<tr>
<td>Capability A</td>
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<tr>
<td>Preliminary Design</td>
<td>Critical Design</td>
<td>Manufacturing</td>
<td>NS-520-1 Launch</td>
<td></td>
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<tr>
<td>NS-520</td>
<td>Avionics component manufacturing and test</td>
<td>Including development test</td>
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<tr>
<td>Capability B</td>
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<tr>
<td>Preliminary Design</td>
<td>Critical Design</td>
<td>Manufacturing</td>
<td>NL-520-1 Launch</td>
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<tr>
<td>NL-520</td>
<td></td>
<td>Development of upper stage motors</td>
<td>Development of GN&amp;C avionics for Nano Launcher</td>
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<tr>
<td>Capability C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercialization &amp; Partnership Planning</td>
<td></td>
<td>Commercial Launcher Development</td>
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<td>Next Gen. Concept Study</td>
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</table>

※ Japanese fiscal year starts on April 1st.

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Nano Launch Vehicle Configuration

<table>
<thead>
<tr>
<th></th>
<th>Existing</th>
<th>Under Planning</th>
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<tbody>
<tr>
<td><strong>S-520</strong></td>
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<tr>
<td><strong>SS-520</strong></td>
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<td></td>
</tr>
<tr>
<td><strong>NS-520</strong></td>
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<td></td>
</tr>
<tr>
<td><strong>NL-520</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Next concept</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Total Length</th>
<th>Diameter</th>
<th>Weight</th>
<th>Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S-520</strong></td>
<td>8.0 m</td>
<td>0.52 m</td>
<td>2.1 ton</td>
<td>1</td>
</tr>
<tr>
<td><strong>SS-520</strong></td>
<td>9.65 m</td>
<td>0.52 m</td>
<td>2.6 ton</td>
<td>2</td>
</tr>
<tr>
<td><strong>NS-520</strong></td>
<td>10.7 m</td>
<td>0.52 m</td>
<td>2.9 ton</td>
<td>2</td>
</tr>
<tr>
<td><strong>NL-520</strong></td>
<td>12.7 m</td>
<td>0.52 m</td>
<td>3.4 ton</td>
<td>4</td>
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</tbody>
</table>

**Avionics Section**

**B0/B1 Separation system**

**B0 Motor (Boost Motor)**

**T.B.D.**
NL-520 Nano Satellite Launcher

**Sequence**
- event : time (s)
  - B0BO : 9.2
  - B1IG : 12.8
  - B1BO : 46.0
  - NFSEP : 110.0
  - B2IG : 120.0
  - B2BO : 144.4
  - B3IG : 302.0
  - B3BO : 332.0
  - Sat. SEP : ~400.0

**Strategies**
- Maximum use of existing components and devices
- Develop light-weight and small, low-cost Avionics system
- Integrate standardized satellite deployment system

Easy access to space

20kg Payload to LEO
Payload Configuration of NL-520

**Now**
- P-POD (US, EU)
- Independent local system (Japan original)

**Future**
- Next Gen. P-POD
- Lighter loading system
- Ingenious design
- Low-cost
- Easy integration
- Easy late access
- Standardization

International cooperation is a key for the successful development of a standardized next generation P-POD.
Small Satellite Launch Vehicle Commercialization Strategy

Technologies and know how derived from the development and operation of Nano launcher will be transferred and applied to current launch vehicles.

Nano Launcher will be a stepping stone for next generation launch vehicles.

- Miniaturized avionics
- High performance motor
- Light-weight structures

Nano Launcher NL-520

Mt ~ 3ton
LEO 20-30kg

50kg Satellite Launcher

Air Launch or Mobile Launch (Clean-sheet)

Mt ~ 7ton
SSO 50kg

US-Japan Cooperative Nano Launcher

Based on NL-520

Mt ~ 3ton
LEO 30kg

Pico-Satellite Launcher

Based on NL-310

Mt ~ 1ton
LEO ~ 3kg

Commercial launcher development
Summary

✓ Nano space technology is strategically developed in major space fairing nations. It brings a major paradigm shift in how we design spacecrafts, launch vehicles and missions.

✓ Employing the evolutionary development scenario originated from S-520 sounding rocket, early demonstration of these key technologies and Nano Launcher capable of lifting 20kg payload to LEO are achieved in a short period.

✓ “Make it smaller and lighter without spoiling performance” is Japanese specialty. IA develops key technologies for Nano Launcher, including high-performance motor and light-weight and low-cost avionics.

✓ Strategic international cooperation is essential to the development of Nano Launcher and marketing of small satellite launch services.

Contact: matsuda-s@iac.ihi.co.jp
Special thanks: Hideki Kanayama (CSP Japan)
Backup Slide
Potential Users of Nano-launcher

- Scientific Mission
- Flying Test Bed for New instruments, Supersonic engine

Two Stage Sounding Rocket

- Sciece Mission (high altitude)
- Technology Demonstrator for Hypersonic engine, Fly-back booster Air-launch system, Re-entry system

Nano Satellite Launch Vehicle

S-520, SS-520

Nano-sat kit


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A-2
Typical Trajectory

Down Range vs. Altitude

Time vs. Velocity, Acceleration

Time vs. Dynamic Pressure, Mach

Performance of NS-520

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IHI Aerospace Products & Composite Technology

- Wide varieties of composite products
  - Aero-Engines
    - V2500 Fan Module FRP Parts
    - Engine Fan FRP Stator Vane
  - 3D shape
    - Solid Rocket FRP Motor Case
    - Solid Rocket FRP Nose Fairing
    - Satellite FRP Pressure Vessel
    - Solid Rocket HIP’d C/C Components

New Composite Components R&D on going
About USEF

Institute for Unmanned Space Experiment Free Flyer: USEF
USEF is a government funded non-profit organization to promote research and development of Space systems and to contribute international space community.

USEF is a public service corporation established in May, 1986, and has been being managed by 13 relating companies under the lead of METI (Ministry of Economy, Trade and Industry).

Location:
2-12 Kanda - Ogawamachi Chiyoda - ku, Tokyo, 101-0052 Japan
URL: http://www.usef.or.jp
Employee: Approximately 30

USEF Space Operation Center (USOC)
In-orbit operations are performed by using JAXA's New Ground Network from USOC in Tokyo
USEF’s main projects
Past and Present Projects

1. **Experiment Reentry Space System (EXPRESS)**
   - **Launch Date**: January 15, 1995
   - **Launcher**: M-3S II
   - **Joint Org.**: DARA/DASA (Germany)
   - **Purpose**:
     - a. Acquisition of technology of re-entry and recovery
     - b. Microgravity experiment
   - **Dimensions**: 1.0m x 2.3m (Height)
   - **Mass**: 765kg (Incl. payloads weight 130kg)
     (Service Module: 360kg, Reentry Module: 405kg)

2. **Space Flyer Unit (SFU)**
   - **Launch Date**: May 18, 1995
   - **Launcher**: H-II
   - **Joint Org.**: MOE/ISAS and STA/NASDA
   - **Purpose**:
     - a. Development of an unmanned platform for experiments and observations in space
     - b. Microgravity experiment
   - **Dimensions**: 4.46m x 3.07m (Height)
   - **Mass**: 3.85ton (Incl. payloads weight 1.0ton)
Past and Present Projects

3. Advanced Robotic Hand System (ARH)
   ◆ Launch Date: November 8, 1997
   ◆ Launcher: H-II
     ARH was launched onboard engineering test satellite-VII(ETS-VII)
   ◆ Joint Org.: STA/NASDA
   ◆ Purpose: Robotic arm experiment for the future precise operation on orbit

4. Unmanned Space Experiment Recovery System (USERS)
   ◆ Launch Date: September 10, 2002
   ◆ Launcher: H-IIA
   ◆ Purpose:
     a. Establishment of space experiment system with self return capability.
     b. Super-conductor Material Processing Experiment
     c. Verification of commercially parts and technologies on the low earth orbit
   ◆ Dimensions: 1.66m x 1.49m x 1.23m (3.5m with REM)
     (SAP Deployment 15.5m)
   ◆ Mass: 1.7ton (Service Module:800kg, Reentry Module:900kg)
Past and Present Projects

5. **Space Environment Reliability Verification Integrated System (SERVIS)**
   - **Launch Date**: SERVIS #1 October 30, 2003
     - SERVIS #2 JFY 2009 (Prearrange)
   - **Launcher**: ROCKOT (SERVIS #1, SERVIS #2)
   - **Purpose**: Development and space verification of advanced experimental equipment with COTS
   - **Dimensions**: 1.65m x 2.5m x 10.2m (SAP Deployment)
   - **Mass**: 840kg

   Study on the space solar power system (SSPS) as an alternative future energy resource
   - Study on the Feasibility of Space Solar Power System
   - Study on SSPS concept
   - Electric power transportation technology by micro wave
   - Evaluation of economy, environment, and safety
Past and Present Projects

7. Advanced Satellite Engineering Research Project (ASER)

ASER is technology development project for next generation spacecraft such as light weight main structure (A-STR), high performance thermal control system (A-TCS), and high energy density Li-ION base battery and power subsystem (A-LIBS), and high performance Hall thruster (A-ION).

The development results except Hall thruster (A-ION) will be applied to Quasi Zenith Satellite System (QZSS), which is joint program of four government ministries, MPHPT, MEXT, METI, and MLIT for the significantly improvement of the accuracy of positioning for Japan by near zenith direction spacecrafts.
8. Advanced Satellite with New System Architecture for Observation (ASNARO)

<Project objectives>
1. To establish new space system architecture to reduce development time and cost of the small satellite bus system.
2. To establish standard small satellite bus system, weighs about 300kg and to be developed within 2 years, for LEO observation spacecraft.
3. To develop high performance optical camera whose resolution is less than 1m from the orbit of 400km altitude.

<ASNARO spacecraft parameter>
1. Panchromatic/Multi-spectral Optical sensor
   - Special resolution (GSD) < 50cm (Pan) at 510km SSO
   - Spectral bands: 6 bands
2. Spacecraft features
   - Downlink rate: 800 Mbps
   - Data storage: 120 Gbytes
   - Pointing Agility: 45 deg/45 sec
   - Design life: < 3 years
   - Weight: 450 kg
   - Launch date: FY2011 (tentative)
9. Feasibility study
9.1 Highly maneuverable earth observation satellite system
- Frequent observation with appropriate orbit.
- Observation area selection by high attitude agility and high orbital agility.

9.2 Air launch system for micro-satellite
- Launch satellite by small rocket from airplane
- Ordinal airport instead of vast launch base
- Minimal constraint for orbit and launch window
About CSP-Japan

• CSP Japan, established in 1987 and located in Tokyo near the central government district, has been providing consulting services to the institutional customers and private space industry.

• CSP Japan is the regional agency and a partner of CSP Associates, Inc., the leading U.S. aerospace and defense consultant. Our global network contributes to Japanese space policy development and the commercial space ventures planning.

• The international market calls for dual-use of space technology and space utilization for socio-economic benefits. CSP Japan serves as an important field player for the global space community.

URL: http://www.csp.co.jp
Contact: webmaster@csp.co.jp